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Oct. 31, 1939. E. M. FOSTER 2,177,629

PIEZOELECTRIC CELL

Filed Jan. 21, 1935

Fig 1

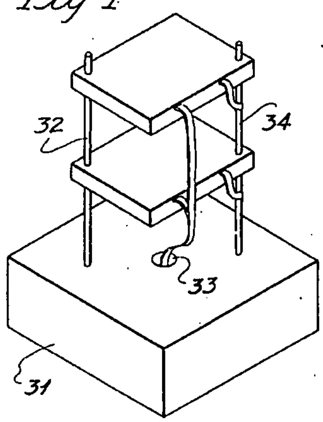

Fig 2

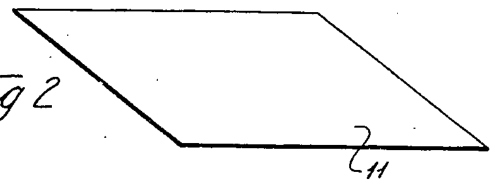

Fig 3

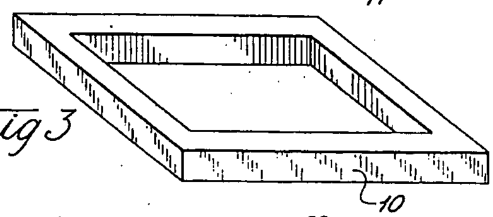

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Fig 4

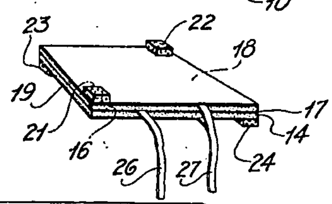


Fig 7

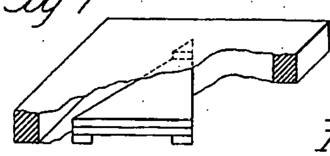


Fig 5

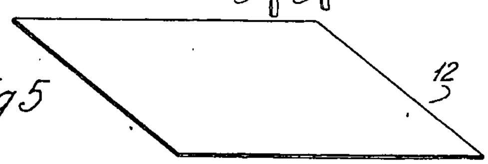


Fig 8

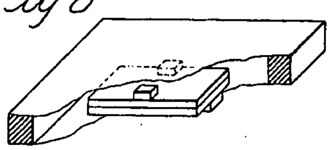


Fig 9

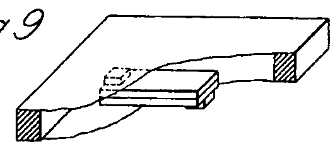
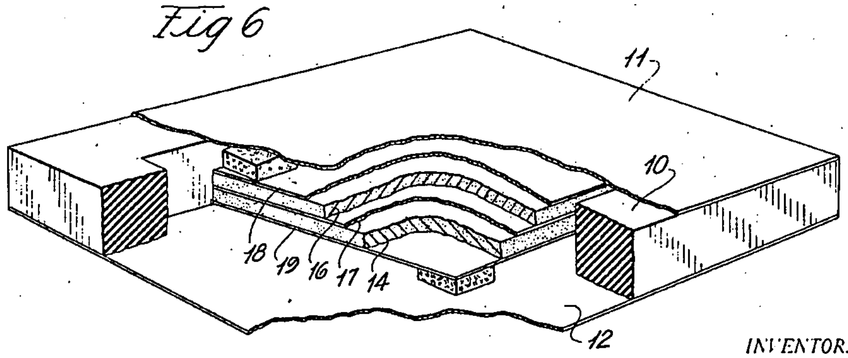


Fig 6



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UNITED STATES PATENT OFFICE

2,177,629

PIEZOELECTRIC CELL

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Application January 21, 1935, Serial No. 2,743

6 Claims. (Cl. 179—110)

This invention relates to piezoelectric cells, or cells comprising an assembly of Rochelle salt crystals or the like together with one or more electrodes constituting a unit adapted to convert electric impulses applied thereto into mechanical impulses and mechanical impulses into electric impulses, and the invention has particular relation to the assembly of the parts of such a cell and holders and supports for the crystals and the cells.

Without attempting a detailed explanation of the phenomena it is a known fact that many materials other than the metallic materials with which we are familiar have fields of force or piezoelectric effect about them and in fact the theory has been advanced that all materials and elements have their own piezoelectric effect. For instance, it is said that orange peels have a marked piezoelectric field. In recent years Rochelle salts have met with considerable favor as a material having a piezoelectric field of sufficient intensity that crystals of the salts may be used in connection with one or more electrodes for converting mechanical impulses into electrical impulses or electrical impulses into mechanical impulses.

One application of the Rochelle salt crystal has been that of acting as a means for controlling the frequency of electric impulses in a given circuit, as for instance in a radio transmitter. Perhaps a less well known use of the piezoelectric crystal such as a Rochelle salt crystal has been as a means of converting mechanical impulses into electric impulses and more specifically for converting the compressions and rarifications of sound waves into electrical impulses which may be amplified and converted into mechanical impulses to produce sound. It is the usual practice in constructing cells utilizing piezoelectric crystals to mount one end of a long substantially rectangular crystal or pair of crystals on a base and attach a diaphragm to the free end of the crystal or crystals whereby pressures and rarifications of the air acting upon the diaphragm produce bending in the crystal to change the configuration of or produce "eruptions" in the surrounding piezoelectric field to produce electrical impulses in the electrodes of the unit.

I have observed, however, that such mountings are not entirely satisfactory and that any disturbance of the base upon which the crystals are mounted produces its own vibration or bending of the crystal and introduces stray electrical impulses into the circuit which in turn produce noise. I have discovered also that much of the noise in the circuit arising by reason of mechanical disturbance of the crystal may be eliminated if the crystal can be supported entirely by the diaphragm or diaphragms and particularly so if the crystal can be suspended from the diaphragm or diaphragms by some shock absorbing elements. I have discovered also that a higher efficiency of the crystal in its capacity as a medium for changing mechanical impulses into electric impulses and vice versa may be secured if the crystal mounting and diaphragm are so located and arranged that the crystal is subjected to a torsional or twisting movement on movement of the diaphragm than when it is subjected merely to a bending movement. I have accordingly devised a means for supporting the crystal unit in suspended relation on a diaphragm or diaphragms and have also devised means for subjecting the crystal to torsional movement on movement of the diaphragm.

A general object of my invention is to provide a new and improved piezoelectric cell.

A more specific object of my invention is to provide a new and improved mounting for a piezoelectric crystal.

Another object of my invention is to provide means for damping out undesirable disturbances which produce noise.

Another object of my invention is to provide a piezoelectric cell and cell mounting such that sound vibrations reaching the cell from any side are equally effective to produce movement of the piezoelectric crystal and thus convert mechanical impulses into electrical impulses or vice versa.

Another object of my invention is to provide means whereby sound impulses produce twisting of a piezoelectric crystal.

Other and further features and objects of my invention will be more apparent to those skilled in the art upon a consideration of the accompanying drawing and following specification, wherein is disclosed an exemplary embodiment of the invention, with the understanding, however, that such changes may be made therein as fall within the scope of the appended claims without departing from the spirit of the invention.

In said drawing:

Figure 1 is a view in perspective of a sound sensitive unit or assembly comprising a plurality of cells mounted on a single base.

Figures 2 to 5 inclusive are views in perspective of the parts of a cell as they appear in exploded relation.

Figure 2 is a view in perspective of one diaphragm.

Figure 3 is a view in perspective of the "frame" in which the piezoelectric crystal is mounted.

Figure 4 is a view in perspective of a crystal comprising, in the present instance, of two crystals and three electrodes together with the mounting means.

Figure 5 is a view in perspective of the other diaphragm.

Figure 6 is a view in perspective of a cell constructed according to one embodiment of my invention. Portions of the cell have been broken away to show the parts thereof.

Figure 7 is a view in perspective of another embodiment of my invention.

Figure 8 is a view in perspective of another embodiment of my invention; and

Figure 9 is a view in perspective of still another embodiment of my invention.

Figures 2 to 6 inclusive are shown in greatly enlarged relation to better show the details of construction.

Referring now to the drawing:

A device constructed according to one embodiment of my invention is comprised of substantially rectangular non-metallic frame 10, such as Bakelite, illustrated more particularly in Figure 3 and on each side of this frame I secure, as by gluing, a pair of diaphragms 11 and 12. These diaphragms are preferably of paper or parchment as I have found that this material is quite suitable both as a means for receiving and transmitting the pressures and rarifications of air produced by sound waves and as a means of damping out stray vibrations which may be set up in the frame 10.

A form of piezoelectric crystal assembly or unit constructed according to a preferred embodiment of my invention, is comprised of a pair of crystals of roughly rectangular form, indicated at 14 and 16, with a sheet of conducting material 17 disposed between the crystals. I preferably employ two other electrodes 18 and 19 disposed one on each of the outer faces of the crystals and then assembling the crystal by gluing the component parts together to form a single unit.

The cutting of the crystal so that its grain runs lengthwise or diagonally determines whether it will be a "bender" in which the long crystals are merely bent, or a "twister" in which the long grains are twisted. Of course the mounting of the crystal also has its effect in determining whether it is a "bender" or a "twister" or whether it is a combination of both.

In preparing the crystals I preferably cut them so that the "grain" of one crystal runs diagonally across the crystal and then cut the second crystal so that the "gain" runs diagonally in a different direction from the grain of the first. By cutting the crystals lengthwise, crosswise or diagonally, and by reason of my mounting structure hereinafter more particularly explained, I may provide any desired "bender" or "twister" type unit or combination. By running the grain in the two or more crystals which make up a unit in different directions I may provide a combination of "benders" and "twisters" or may provide combinations of "bender" crystals.

In order to mount the crystal assembly so that the diaphragms will impart the greatest relative bending effect to the crystals and in order that the crystal assembly may be suspended so stray vibrations do not readily reach the crystals, I preferably mount the crystal assembly on small pads which in turn are supported by both diaphragms. Furthermore, in order to still further intensify the torsional effect on the crystal, I prefer to cut the crystals in a rhomboid figure and have found that the trapezoidal figure illustrated in Figure 4 is one of the most suitable for the purpose.

In mounting the crystal unit illustrated in Figure 4 within the diaphragms 11 and 12, I preferably provide small rectangular pads of cork or the like and mount two of the pads on opposite corners of one face of the assembled unit, illustrated at 21 and 22, and mount two more pads at the opposite corners of the other exposed face of the assembled crystal unit, as illustrated at 23 and 24. The thickness of the pads 21, 22, 23 and 24 and of the frame 10, and of course the crystal unit, is so chosen that the over-all thickness of the crystal unit is the same or approximately the same as the thickness of the frame. In assembling the unit I apply a sticky substance such as Bakelite cement to the exposed faces of the pads and to the upper and lower faces of the frame, place the crystal units in the frame with the leads 26 and 27 leading respectively from the inner electrode and from the two outer electrodes so that one lead projects between the diaphragm and the frame on one side of the frame and the other lead projects between the frame and the other diaphragm, and then place the diaphragms on the frame and apply sufficient pressure to glue the assembly into one sound sensitive unit or cell.

In providing a cell suitable for sound reception I may employ a plurality of units such as illustrated in Figure 1, in which case I provide a base 31 and a plurality of standards 32 and 34 mounted in the base and projecting upwardly therefrom. The sound sensitive cells are then placed on the standards with the standards passing through opposite corners of the frame. The cells are located at spaced intervals as illustrated and preferably in parallel horizontal planes. One set of leads are brought out and connected to an insulated lead as indicated at 33, and the other set of leads are brought out to a standard such as the standard 34. Electrical connection is made with the leads 33 and standard 34 to a source of electric current (not shown) and to the first step of a radio frequency amplifier or other circuit. I prefer to employ more than two cells and have found that six such cells work well, for instance, as a microphone. The cells may be connected in series, parallel or series parallel relation as desired. The voltage produced in the electrodes may be varied by varying the number of cells in series and the impedance varied by varying the number of cells in parallel.

It is quite apparent, when a compression of air, as produced by a sound wave, strikes the opposed diaphragms 11 and 12, that the pads 21 and 22 will be forced downwardly and tilted in opposite directions while the pads 23 and 24 are forced upwardly and also tilted in opposite directions. It is apparent also that the crystals will be twisted through this opposed movement of the pads and that relative movement of the crystals results, which movement is pure bending, pure twisting or a combination of the two depending on how the crystals have been cut and assembled. If the grain of the two crystals which make up the crystal assembly runs in opposite direction and if the crystals themselves are cut in a trapezoidal form, it is apparent that the torsional effect is intensified. Conversely, if a rarification strikes the diaphragm, the opposed pads are

pulled apart to bend or twist the crystal in the opposite direction.

It is apparent that other modifications of my invention may be made by those skilled in the art. For instance the crystals may be of triangular form supported at two corners and having the third corner engaged to a diaphragm (Figure 7). They might be supported at the sides of the crystals instead of the ends (Figure 8), or they might be supported from the opposed diaphragms at two points only (Figure 9).

I claim as my invention:

1. A piezoelectric cell comprising a pair of diaphragms, a piezoelectric crystal, and cushioning means for suspending the crystal from the inner faces of the diaphragms.

2. A piezoelectric cell comprising a pair of diaphragms, a piezoelectric crystal, cushioning means for mounting the crystal on the inner face of one of the diaphragms and means for driving the crystal from the inner face of the other diaphragm.

3. In a piezoelectric cell, a pair of diaphragms, a piezoelectric crystal of triangular shape disposed between the diaphragms, a pair of spaced resilient pads on one of the faces of the crystal, and a third resilient pad on the other face of the crystal with the respective pads engaged to the inner faces of the diaphragms.

4. In a piezoelectric cell, a pair of diaphragms, a piezoelectric crystal disposed between the diaphragms, a resilient damping pad on one face of the crystal engaged to the inner face of one of the diaphragms, and a resilient damping pad on the other face of the crystal engaged to the other of the two diaphragms.

5. A piezoelectric crystal unit comprising at least two crystals cut in trapezoid shape with the grain of the two crystals running in different directions placed one on the other, an electrode between the crystals, electrodes on the exposed faces of the crystals electrically connected to each other, a pair of resilient damping pads on opposite corners of one of the exposed faces of the crystal, another pair of resilient damping pads on opposite corners of the exposed face of the other crystal and the second pair of pads being oppositely disposed to the first pair, and a diaphragm attached to each pair of pads.

6. A piezoelectric crystal unit comprising at least two crystals cut in trapezoid shape with the grain of the two crystals running in opposite directions placed one on the other, an electrode between the crystals, electrodes on the exposed faces of the crystals electrically connected to each other, a pair of resilient damping pads on opposite corners of one of the exposed faces of the crystal, another pair of resilient damping pads on opposite corners of the exposed face of the other crystal and the second pair of pads being oppositely disposed to the first pair, a diaphragm attached to each pair of pads and a frame surrounding the crystals, electrodes and pads and the diaphragms being attached to the frame on opposite sides thereof.

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